Claims

We claim:

1. A method for shaping a spectrum of an impulse radio signal, comprising:

generating a set of basis pulses at a plurality of frequencies and a plurality of random delays;

weighting the set of basis pulses by weights;

delaying the set of basis pulses by delays; and

combining linearly the weighted and delayed basis pulses to conform the spectrum to a spectral mask.

2. A method of claim 1 further comprising:

shifting frequencies of the weighted and delayed basis pulses before the combining.

3. The method of claim 1 wherein the weights and delays are fixed over time for a predetermined spectral mask.

4. The method of claim 1 wherein the weights and delays vary over time to adaptively shape the spectrum.

5. The method of claim 1 wherein the basis pulses are Gaussian in form.

6. The method of claim 1 wherein the weighting and delaying are performed by a set of filters and a set of delay lines, and the combining is performed by an adder.

7. The method of claim 1 further comprising:

evaluating a cost function to determine the weights and delays.

8. The method of claim 7 wherein the cost function, f, includes first and second functions f_1 and f_2, and

$f(\underline{p}(t), S) = \alpha f_1(\underline{p}(t)) + \beta \sum_{M(\Omega) \in S} f_2(\underline{p}(t), M(\Omega))$, where α and β are predetermined constants, $S = M(\Omega)$ denote the spectral mask, and $\underline{p}(t)$ denotes the set of basis pulses, and the first function f_1 models a cost of generating the basis pulses, and the second function f_2 models an approximation error.

9. The method of claim 1 wherein the delays are fixed, and further comprising:

solving a quadratic optimization problem to approximately minimize a deviation from the spectral mask.

10. The method of claim 9 further comprising:

refining the weights and delays by a non-linear optimization.

11. The method of claim 10 wherein the non-linear optimization is performed by a back-propagation neural network.

12. The method of claim 10 wherein the non-linear optimization is performed by a multiple-layer neural network

13. The method of claim 10 wherein the non-linear optimization is performed by a simulated annealing process.

14. The method of claim 1 wherein the weights and delays are jointly optimized as a solution to a quadratic optimization problem to approximately minimize a deviation from the spectral mask.

15. The method of claim 1 further comprising:

selecting the set of basis pulses from a candidate set of basic pulses by greedy addition to optimizing the delays.

16. The method of claim 1 further comprising:

selecting the set of basis pulses from a candidate set of basic pulses by greedy removal to optimizing the delays.

17. The method of claim 1 further comprising:

orthogonalizing and normalizing the set of basis pulses; and

applying a branch and bound procedure to the set of orthogonalized and normalized basis pulses to optimize the delays.

18. The method of claim 17 wherein bounds of the branch and bound procedure are determined by Cauchy's interlacing theorem of eigenvalues for symmetry matrices.

19. The method of claim 17 wherein the branch and bound procedure further comprises:

constructing an enumeration tree with an increasing number of zeros in vectors representing the delays.

20. The method of claim 1 wherein the basis pulses are selected off-line from a set of basis pulses by a combinatorial optimization using training spectral masks.

21. A system for shaping a spectrum of an impulse radio signal, comprising:

means for generating a set of basis pulses at a plurality of frequencies and a plurality of random delays

a set of filters configured to weight the set of basis pulses by weights;

a set of delay lines configured to delay the set of basis pulses by delays; and

an adder configured to combine linearly the weighted and delayed basis pulses to conform the spectrum to a spectral mask.

22. The system of claim 21 further comprising:

a set of oscillators configured to shift frequencies of the weighted and delayed basis pulses before the combining.

Abstract of the Disclosure

A method and system shapes a spectrum of an impulse radio signal, such as an UWB signal. First, basis pulses at various frequencies and pseudo-random delays are generated. The generated set of basis pulses are then weighted and delayed, and combined linearly to conform the spectrum of the transmitted basis pulses to a spectral mask. The spectral mask can be predetermined, or the conforming can be adaptive. Furthermore, the basis pulses can be frequency-shifted before the combining.